RESEARCH HIGHLIGHT

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Technical Series 04-129

DURABLE WOOD-FRAME CONSTRUCTION FOR ALL CLIMATIC ZONES: A COMPANION TO CANADIAN WOOD-FRAME HOUSE CONSTRUCTION

INTRODUCTION

Wood-frame construction, which is well developed and accepted in North America, is beginning to be exported—thanks, in large part, to the efforts of Canadian designers, builders and suppliers—to climatic zones where it has been little used.

It is essential for the long-term viability of wood-frame construction in new markets that it proves to be durable. Canada Mortgage and Housing Corporation (CMHC) commissioned *Durable wood-frame construction for all climatic zones: A companion to Canadian wood-frame house construction* to supplement *Canadian wood-frame house construction*, CMHC's popular reference book. The intent is to support Canadian builders, designers and suppliers in offshore markets and at home.

Part I of the three-part *Durable wood-frame construction for all climatic zones* deals with well-established building science principles for building envelope durability.

Part II breaks new ground, with methods allowing a designer or builder to select a particular wall construction based on local site conditions. The local conditions are based on climatic data from a weather database on NASA's (U.S. National Aeronautics and Space Administration) website

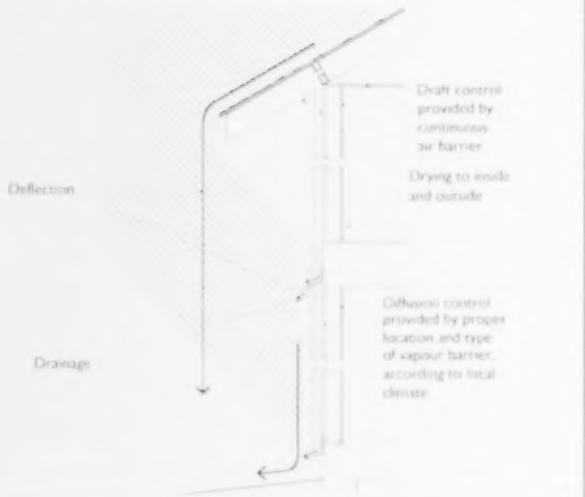
Part III gives examples of durable wood-frame building assemblies for the world's climate zones.

Below are point-form summaries and sample illustrations from Parts I, II and III of *Durable wood-frame construction for all climatic zones*.

PART I

- The building science principles of building envelope durability.
- The 5 Ds of moisture control, deflection, drainage, draft control, drying ability and diffusion control.
- Concealed barrier, drainscreen and rainscreen exterior wall cladding systems.
- Air barrier systems.
- Vapour barrier types and their locations with building assemblies.
- Durable foundation construction for both moisture control and termite prevention.
- Whole-house natural and mechanical ventilation for cooling and indoor air quality.

Figure 1-The 5 Ds of moisture control



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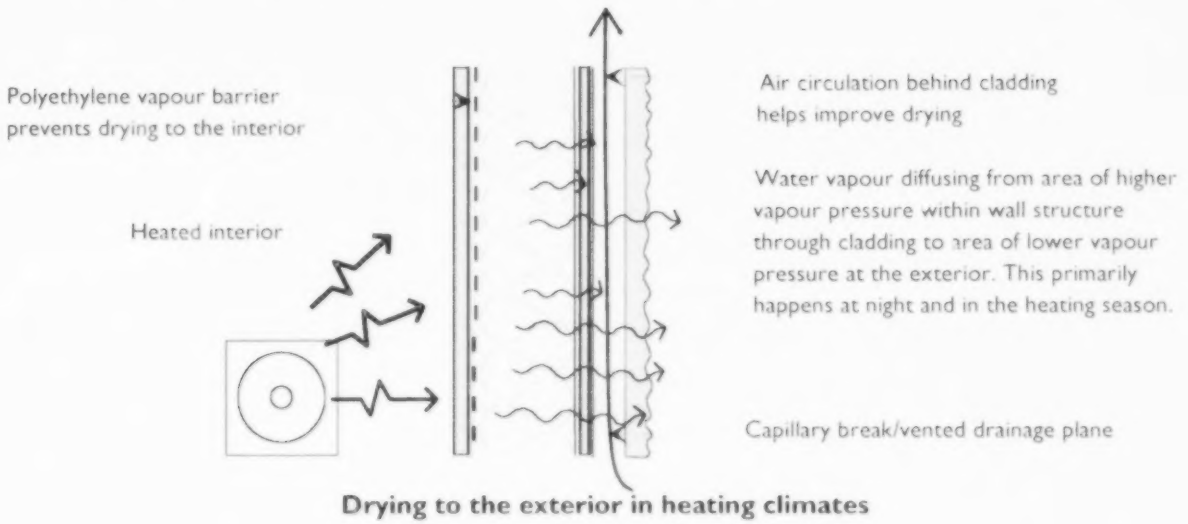
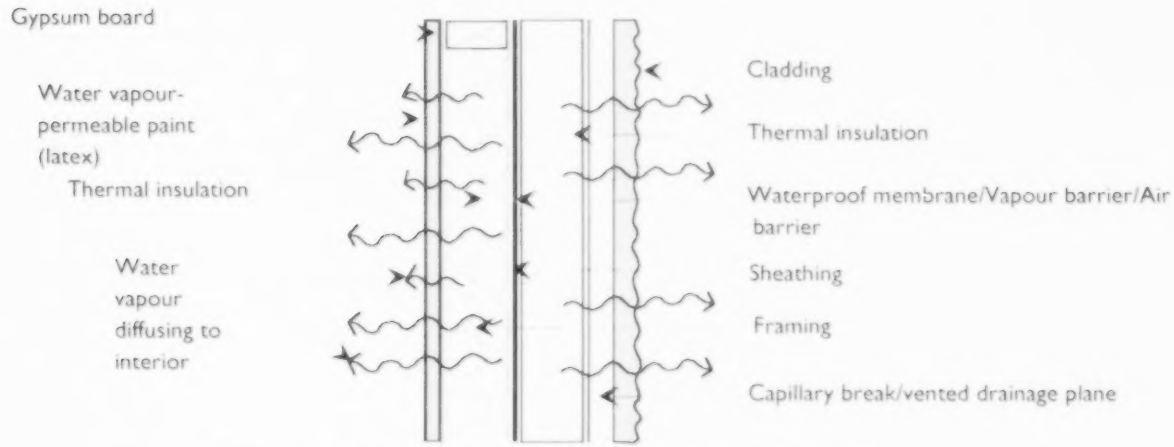
HOME TO CANADIANS

Canada

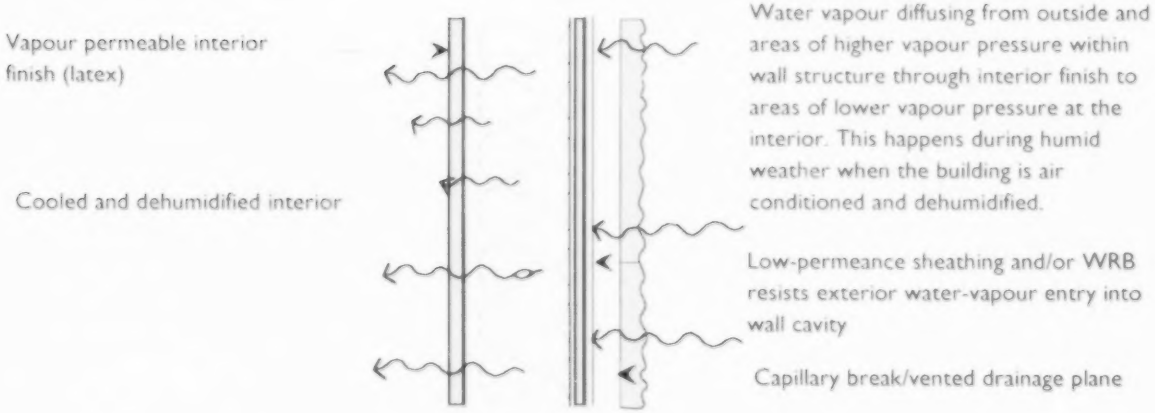
Figure 2-Examples of drying in different wood-frame wall assemblies


Polyethylene vapour barrier prevents drying to the interior
Heated interior
Air circulation behind cladding helps improve drying
Water vapour diffusing from area of higher vapour pressure within wall structure through cladding to area of lower vapour pressure at the exterior. This primarily happens at night and in the heating season.
Capillary break/vented drainage plane

Drying to the exterior in heating climates

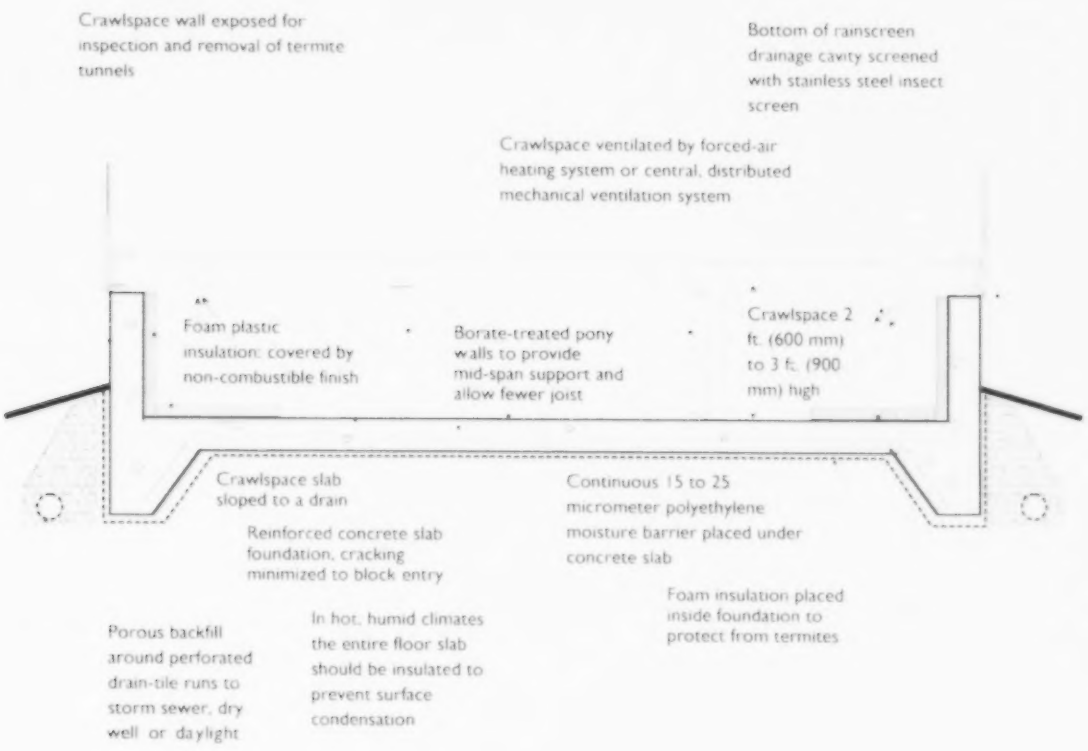


Drying to the interior and exterior in mixed climates


Vapour permeable interior finish (latex)
Cooled and dehumidified interior
Water vapour diffusing from outside and areas of higher vapour pressure within wall structure through interior finish to areas of lower vapour pressure at the interior. This happens during humid weather when the building is air conditioned and dehumidified.
Low-permeance sheathing and/or WRB resists exterior water-vapour entry into wall cavity
Capillary break/vented drainage plane

Drying to the interior in hot, humid climates

Figure 3-Crawlspace foundation for warm and hot climates is heated, cooled and ventilated in the same manner as the rest of the house. In hot, humid climates, the entire floor slab may need insulation to prevent condensation formation.


Crawlspace wall exposed for inspection and removal of termite tunnels
Bottom of rainscreen drainage cavity screened with stainless steel insect screen
Crawlspace ventilated by forced-air heating system or central, distributed mechanical ventilation system
Foam plastic insulation: covered by non-combustible finish
Borate-treated pony walls to provide mid-span support and allow fewer joist
Crawlspace 2 ft. (600 mm) to 3 ft. (900 mm) high
Crawlspace slab sloped to a drain
Reinforced concrete slab foundation, cracking minimized to block entry
Continuous 15 to 25 micrometer polyethylene moisture barrier placed under concrete slab
Foam insulation placed inside foundation to protect from termites
Porous backfill around perforated drain-tile runs to storm sewer, dry well or daylight
In hot, humid climates the entire floor slab should be insulated to prevent surface condensation

PART II

- A method for identifying the climatic zone of every one-degree of latitude and longitude of the earth's surface. Once the user knows a site's latitude and longitude, the user can find the site's climatic zone. This method uses a free database on a NASA website with climatic information from satellites and ground-based stations.
- Information other than climate zone information that designers might find useful.
- Categorization of climates for design in North America.
- Examples of categorizing climates in different parts of the world using the same approach.
- Definitions of climatic zones.
- Classification of rain-wind climatic factors ("Environmental Climatic Index"—ECI).
- Determining rain and moisture tolerance of wall assemblies ("Moisture Tolerance Index" or MTI).
- Required MTI values for walls exposed to specific rain-wind ECI conditions.
- Placing barriers.
- Climatic effects not addressed by building codes.
- Modifying conventional building systems for use in a wider range of climates.

PART III

- Descriptions and illustrations of sample building assemblies for the climatic zones defined in Part II.

The following is a sample building assembly for one climatic zone, with an accompanying graphic.

WALL FOR MIXED AND HUMID, OR MARINE CLIMATES

Figure 4 is a cross-section of an exterior wall and details at the intermediate floor, at the roof and at the foundation for a wood-frame wall built with 2x4 (38x89 mm) or 2x6 (38x140 mm) framing.

Figure 4-Wall for mixed and humid or marine climates

Platform frame 2x4 (38x89 mm) inverted wall, Peel-and-Stick AVB

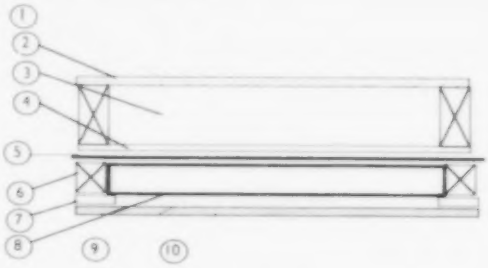
Wood-Frame structure: Studs @ 16" or 24" O.C (400 to 600 mm O.C)
Cladding: Stucco, wood, vinyl, fiber cement board, metal

Climate(s): marine, mixed humid (MMH)

Components: Exterior wall, roof, foundation, intermediate floor

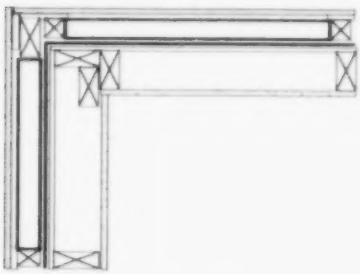
Overview and comments

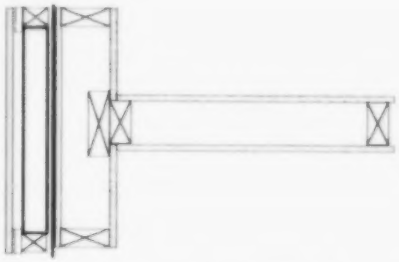
1) Vapour-permeable coating
2) Gypsum wall board
3) Empty wall cavity for mechanical and electrical
4) Plywood or OSB sheathing
5) Peel-and-stick waterproof membrane air barrier, vapour barrier and moisture barrier
6) Preservative-treated shear blocks for seismic areas or where insulation requires
7) 3/8" to 3/4" (10 mm to 19 mm) preservative-treated vertical strapping
8) Rigid or semi-rigid insulation
9) Drainage and ventilation air space
10) Cladding

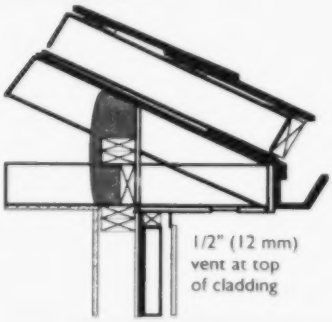


Insulation options: Extruded polystyrene, expanded polystyrene, rigid fiber glass board, mineral wool board, spray urethane foil-faced urethane foam board, EPS

Notes on construction

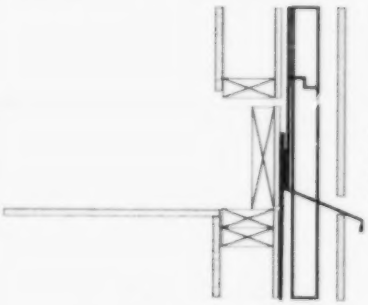




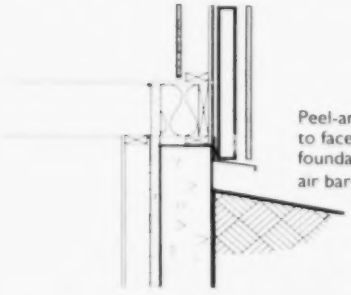


Urethane spray foam carries air barrier from exterior wall to roof sheathing that is covered in peel-and-stick membrane

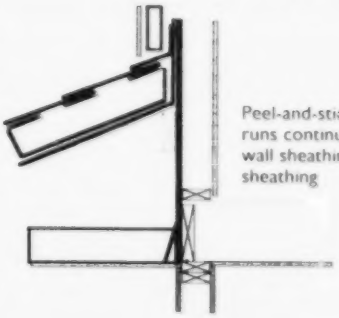
1/2" (12 mm) vent at top of cladding



Cross-cavity flashing to direct water out of the cavity behind cladding



Peel-and-stick sealed to face of concrete foundation to provide air barrier continuity



Peel-and-stick membrane runs continuously down wall sheathing onto roof sheathing

The paint layer (1) on drywall (2) has a vapour permeance between 5 and 10 perms (or 280-570 ng/m²sPa). A primer sealer and a finish coat of latex paint achieve this level of water vapour retardation. The wood-frame cavity (3) is either left unfilled or a thin layer, as a rule less than 1-in. (25 mm) thick, continuous layer of spray polyurethane foam provides an internal air barrier. An impermeable membrane (5) is typically sandwiched between the OSB or plywood sheathing (4) and the exterior thermal insulation (8) to provide the required degree of air and moisture control. This membrane functions as the air barrier, vapour retarder and moisture barrier.

Typically, the membrane (5) is peel-and-stick, with water-vapour permeance lower than that of the paint, that is, 0.2 to 0.6 perm (12 to 35 ng/m²sPa) and air permeance lower than 0.02 l/m²sPa. The exterior thermal insulation is typically either extruded polystyrene, faced polyisocyanurate or spray-applied medium (or high) density polyurethane foam. In this system, the thermal insulation must be resistant to water penetration either by its nature or be provided with water-impermeable facing. It has to provide a drainage plane and protection from reverse moisture drive, that is, moisture driven from a porous, rain-soaked cladding into the wall by the solar radiation.

The ¾ in. to ¾ in. (10 mm to 19 mm) thick preservative-treated furring strips (7) are oriented vertically and secured with corrosion-resistant fasteners. In seismic locations and with heavier cladding, vertical preservative-treated shear blocks are used; refer to a structural engineer.

A critical part of rainscreen design is the provision of drainage and venting space (9) at the top of the wall and at intermediate floors or foundation. At the top of the wall, the designer typically provides a ½-in. (12 mm) gap between the top of the cladding and the underside of the soffit to allow for venting. At the bottom of the wall and at intermediate floors, the cladding is vented and flashed to direct any water from the space to the outside. Screened mesh is incorporated at all vents to keep insects out.

All window and door heads and mechanical penetrations must be flashed with flashing that extends up 4 in. (100 mm) behind the sheathing membrane, past through the drainage cavity and out 1 in. (25 mm) beyond the face of the cladding. Roof overhangs extending out a minimum of 2 ft. (600 mm) also protect the wall immediately below and should be used where possible.

Figure 4 shows that the same general principles of construction are applied to ceilings as to the wall system. A sheet of peel-and-stick is applied to the roof sheathing, forming the air barrier with the rigid foam insulation applied over that. The attic space is sealed from the outside, using spray urethane foam. This makes the attic space part of the conditioned volume of the building. Only the soffit is vented to the outside. This approach also has the advantage of allowing ductwork to be run in indoor conditions in the attic space, reducing heat losses and gains through the ductwork.

IMPLICATIONS

Building wood-framed construction in various climates has largely been done with little modification in Canada and other parts of North America except for satisfying thermal requirements. This has led to some inappropriate installations and poorer durability, particularly in hot, humid climates. *Durable wood-frame construction for all climatic zones* provides a framework around which different climatic zones can be identified in North America and the world and suggests a range of specific systems for each construction zone.

The document is set up with this prime, common-sense imperative:

> The priority for dealing with moisture is to ensure that the major sources are addressed first in design. This means providing moisture control in the following order-rain control, air-leakage control and, finally, vapour-diffusion control.
>
> The second imperative is that every house is a system, and many things affect its performance. The builder needs to consider how roofs, foundations and heating-cooling-ventilation systems—all needed for occupant comfort—interact.

While the general knowledge in *Durable wood-frame construction for all climatic zones* can be applied to construction in North America, it also applies to other parts of the world where wood-framed construction can provide affordable, energy efficient and safe housing. Builders should also always be sensitive to cultural differences in how people use their living spaces. Building codes in other countries as well of local knowledge about materials and the climate should also be factored in to produce appropriate designs in these other jurisdictions.

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